FIRST MEASUREMENT OF TARGET SPIN ASYMMETRY IN DEEPLY VIRTUAL COMPTON SCATTERING

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FOR THE CLAS COLLABORATION

New preliminary results will be discussed for the target spin asymmetry in exclusive Deeply Virtual Compton Scattering(DVCS). The asymmetry is the result of interference between the DVCS and the Bethe-Heitler amplitude.

1. Introduction

The recently developed formalism of "Generalized Parton Distributions" (GPDs)[1 2 3] contains new information on the internal structure of nucleons. In hard exclusive leptoproduction, this nucleon information can be parameterized, at leading twist-2 level, in terms of four generalized structure fuctions, $\mathcal{H}(x,\xi,t)$, $\tilde{\mathcal{H}}(x,\xi,t)$, $\mathcal{E}(x,\xi,t)$, and $\tilde{\mathcal{E}}(x,\xi,t)$, where x is the momentum fraction of the struck quark in the quark loop, ξ is the logitudinal momentum fraction of the four momentum transfer Δ, and $t = \Delta^2$ is the standard momentum transfer between the virtual photon and the final state.

In the forward limit, GPDs $\mathcal{H}$ and $\tilde{\mathcal{H}}$ reduce to the ordinary parton distributions $q(x)$ and $\Delta q(x)$ respectively[4]. With a sum rule, GPDs can be related to the ordinary nucleon form factors[4]. Also Ji[2] has shown that the first moment of the GPDs gives access to the sum of the quark spin and the quark orbital angular momentum to the nucleon spin. Therefore, GPDs provide a unifying picture for an entire set of fundamental quantities describing hadronic structure.

Deeply virtual compton scattering (DVCS) is one of the simplest reactions which constrain GPDs experimentally. Using the beam energies available at JLab, the cross section for DVCS is small, and it is masked by the more copious production of photons from the Bethe-Heitler (BH) process (see Figure 1). However, with a polarized electron beam or a polarized target, the DVCS/BH interference term which is related to the GPDs, can be isolated. Actually, the well-known BH term amplifies the much smaller DVCS term which depends on the unknown GPDs. The measured cross section of the reaction $ep \to ep\gamma$ is :

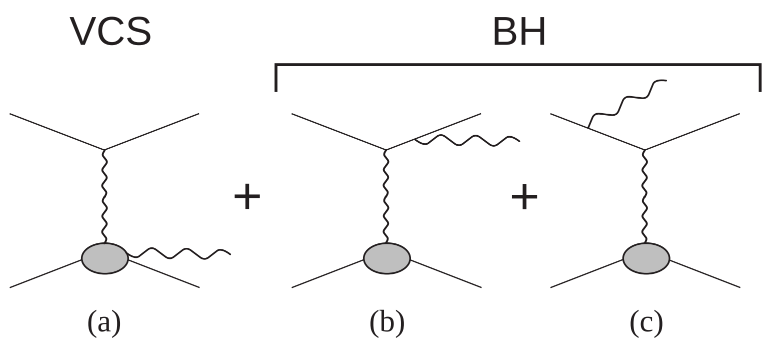

Figure 1. Feynman diagrams for the DVCS process (left) and Bethe-Heitler process(right).

$$\frac{d^5\sigma}{dx_B dy dt d\phi d\varphi} \propto |\mathcal{T}_{BH}|^2 + |\mathcal{T}_{DVCS}|^2 + \mathcal{I}, \tag{1}$$

where the BH/DVCS interference term is given by

$$\mathcal{I} = \mathcal{T}_{DVCS}\mathcal{T}^*_{BH} + \mathcal{T}^*_{DVCS}\mathcal{T}_{BH} \tag{2}$$

With a polarized electron beam, the beam spin asymmetry (A_{LU}) can be measured to access GPDs, and its azimuthal dependence is approximately given by the $\sin(\phi)$ function[5]:

$$A_{LU}(\phi) \propto \Im\{F_1\mathcal{H} + \frac{x}{2-x}(F_1+F_2)\tilde{\mathcal{H}} - \frac{\Delta^2}{4M^2}F_2\mathcal{E}\}\sin(\phi), \tag{3}$$

where F_1, F_2 are the Dirac and Pauli form factors of the nucleon, M is the rest mass of the proton, and ϕ is the angle betweent the scattering plane and the reaction plane. Since both x and Δ^2 are typically small, $\mathcal{H}$ can be determined from A_{LU}. The first experimental results for A_{LU} are availabe from the HERMES[6] and CLAS[7]collaborations.

With a logitudinally polarized target, the target spin asymmetry (A_{UL}) can be measured to access GPDs, and its azimuthal dependence is approximately given by the $\sin(\phi)$ function[5]:

$$A_{UL}(\phi) \propto \Im\{\frac{x}{2-x}(F_1+F_2)(\mathcal{H}+\frac{x}{2}\mathcal{E})+F_1\tilde{\mathcal{H}}-\frac{x}{2-x}(\frac{x}{2}F_1+\frac{\Delta^2}{4M^2}F_2)\tilde{\mathcal{E}}\}\sin(\phi) \tag{4}$$

Since again both x and Δ^2 are small ($< x > = 0.282$, $< -\Delta^2 > = 0.301$ in this experiment), A_{UL} is mostly sensitive to $\tilde{\mathcal{H}}$.

2. Experimental Setup

The data for this analysis were taken from Sep. 2000 through Apr. 2001 with the CLAS[8] detector in Hall-B at Thomas Jefferson Laboratory in Newport News, VA. A longitudinally polarized 5.7 GeV electron beam was directed onto a solid $^{15}NH_3$ target, which was dynamically polarized parallel to the beam direction[9]. The target polarization was on average 70%, and was frequently reversed to help control systematics. Data were also taken with a solid ^{12}C target for unpolarized nitrogen background studies.

3. Event Selection

Since our DVCS process is $e\vec{p} \to e'p\gamma$, events were selected requiring exactly one negatively charged particle, exactly one positively charged particle, and exactly one neutral particle. To select Deep Inelastic Scattering (DIS) events, W was required to be greater than 2 GeV and Q^2 greater than 1 GeV^2.

The main sources of background to the DVCS/BH processes are from $ep\gamma$, where photons are from unpolarized nitrogen, and from $ep\pi^0(\gamma\gamma)$ where only one of the two photons is detected. To isolate the single photon events from polarized hydrogen, we can compare the expected properties (the energy and the polar angle θ) of a "calculated" photon $X(e\vec{p} \to e'pX)$ with a detected photon $\gamma(e\vec{p} \to e'p\gamma)$. Due to the Fermi motion of the protons from unpolarized nitrogen, the "calculated" photon X is very different from the detected γ for the events from nitrogen. Such differences also exist for $ep\pi^0$ events, when only one of two photons is detected.

After all the above cuts, the DVCS/BH events are well selected. Figure 2 shows a comparison of the results on the two targets, where the carbon target is used to simulate the unpolarized nitrogen.

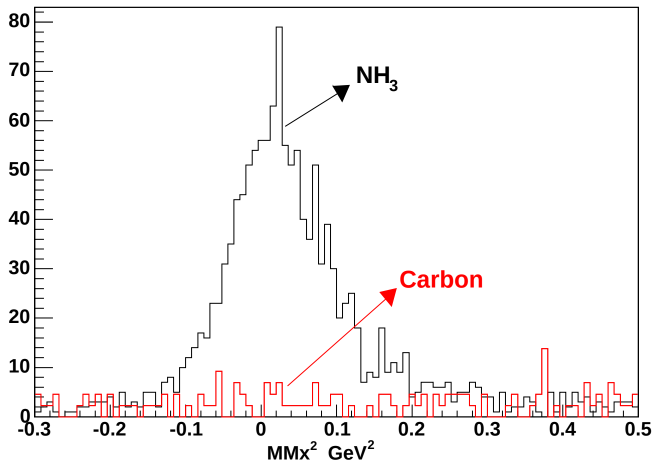

Figure 2. Missing mass squared distribution for the reaction $e\vec{p} \rightarrow e'pX$ for single detected photon events; they are normalized to each other using the negative MMx^2 tail.

4. Preliminary Results

The selected single photon events are used to calculate the target spin asymmetry as:

$$A_{UL}(\phi) = \frac{1}{P_t} \frac{N^{\uparrow}(\phi) - N^{\downarrow}(\phi)}{N^{\uparrow}(\phi) + N^{\downarrow}(\phi)} \tag{5}$$

where P_t is the target polarization, $N^{\uparrow(\downarrow)}$ is the luminosity-normalized number of $e\vec{p} \rightarrow e'p\gamma$ events at positive (negative) target helicity, and the subscripts U and L denote an unpolarized beam and a logitudinally polarized target.

In Figure 3, the azimuthal dependence of the measured target spin asymmetry A_{UL} is shown. Data in each ϕ bin are integrated in the range of Q^2 from 1 GeV^2 to 3.5 GeV^2 and $-t$ from 0.1 GeV^2 to 0.6 GeV^2. The data points are fitted with the function $A_{UL}(\phi) = p_1 \sin(\phi)$. The fitted parameter is $p_1 = 0.249 \pm 0.050$. The model calculation[10] is also given.

5. Outlook

Due to the finite spatial resolution of the electromagnetic calorimeter (EC)[11], high energy π^0 events can be misidentified as single photons. High

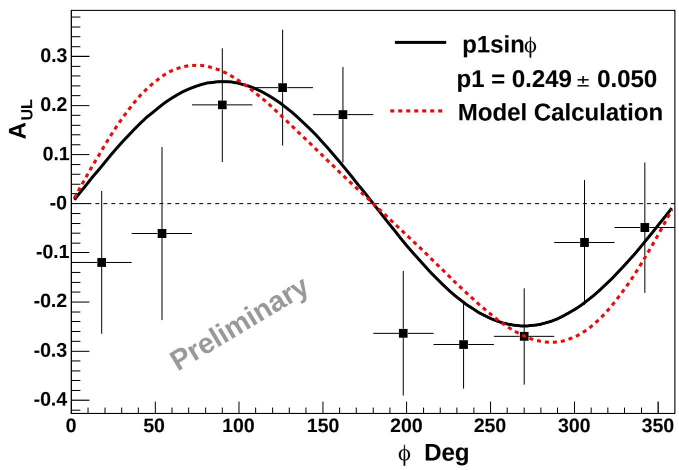

Figure 3. Azimuthal dependence of the measured target spin asymmetry. Solid curve is the fitted function, and dashed curve is the model calculation.

energy π^0 decay into two photons which both hit the calorimeter at nearly the same position and are often mistakenly reconstructed as a single high energy photon. Consequently, the current event sample is contaminated by such π^0 events. Monto Carlo(MC) simulations are being carried out to estimate the π^0 contamination. To correct the target spin asymmetry for DVCS, the target spin asymmetry for π^0 will be measured using events which are clearly π^0. Radiative corrections and systematic errors will also be studied in the near future.

References

1. D. Müller *et al.*, *Fortschr. Phys.* **42**, 2101 (1994).
2. X. Ji, *Phys. Rev. Lett.* **78**, 610 (1997).
3. A.V. Radyushkin, *Phys. Lett. B* **380**, 417 (1996).
4. K. Goeke, M. V. Polyakov and M. Vanderhaeghen, *Prog. Part. Nucl. Phys.* **47**, 401 (2001).
5. A. Belitsky, D.Müller and A.Kirchner, *Nucl. Phys.* **B629**, 323 (2002).
6. A. Airapetian *et al.*, *Phys. Rev. Lett.* **87**, 182001 (2001).
7. S. Stepanyan *et al.*, *Phys. Rev. Lett.* **87**, 182002 (2001).
8. B.A. Meching *et al.*, *Nucl. Instr. and Meth. A* **503**, 513 (2003).
9. C.D. Keith *et al.*, *Nucl. Instr. and Meth. A* **501**, 327 (2003).
10. M. Vanderhaeghen *et al.*, *Phy. Rev. D* **60**, 094017 (1999).
11. M. Amarian *et al.*, *Nucl. Instr. and Meth. A* **460**, 239 (2001).